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ABSTRACT

The present investigation employed Kahneman and Tversky's (1973) "Cab Problem" and the "Shuttle Problem" (a modified version of the former) in two separate experiments to further examine the impact of several variables on the utilization of base-rate information, and to what extent gender is related to the utilization of non-diagnostic base-rate information. Experiment One tested 216 tested undergraduate students to investigate the effects of gender, order of information, and the accuracy of case-specific information on the utilization of diagnostic base-rate information. Diagnostic base-rate information in Experiment One was information that should have been incorporated into subjects' probability estimates. Significant main effects were found for "Order of Information" and "Witness Accuracy Rate". In Experiment Two, non-diagnostic base rates were presented to 155 undergraduates. Non-diagnostic base rates were information that should not have been incorporated into individuals' probability estimates. Significant main effects for "Gender" and "Out-of-Commission Rate" suggest that subjects encounter difficulty when deciding what type of information is relevant to word problems and that quite possibly, individual differences and inappropriate applications of basic arithmetic may be responsible for some errors in more traditional base-rate investigations. (ABL)

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Gender and the Utilization of Base-Rate Information

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Running Head: Gender and Base Rates

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Abstract

The present investigation employed Kahneman and Tversky's (1973) "Cab Problem" and the "Shuttle Problem" (a modified version of the former) in two separate experiments to further examine (1) the impact of several variables on the utilization of base-rate information, and (2) to what extent gender is related to the utilization of non-diagnostic base-rate information. Experiment One tested 216 undergraduate students at the University of Vermont to investigate the effects of gender, order of information, and the accuracy of case-specific information on the utilization of diagnostic base-rate information. Diagnostic base-rate information in Experiment One was information that should have been incorporated into subjects' probability estimates (i.e., at least according to Bayes' theorem). Significant main effects were found for "Order of Information" and "Witness Accuracy Rate" (i.e., the accuracy of the case-specific information). In Experiment Two, non-diagnostic base rates ("Out-of-Commission Rates") were presented to 155 undergraduates. Non-diagnostic base rates were information that should not have been incorporated into individuals' probability estimates. Significant main effects for "Gender" and "Out-of-Commission Rate" suggest that subjects encounter difficulty when deciding what type of information is relevant to word problems and, that quite possibly, individual differences and inappropriate applications of basic arithmetic may be responsible for some errors in more traditional base-rate investigations. Criticisms of past and current research and possible directions for future research are addressed.

Gender and the Utilization of Base-Rate Information

Over the past several decades, social scientists have extensively investigated (1) gender differences in quantitative ability and (2) base-rate utilization. Perhaps an interesting question one might pose as a result of this work is how do gender-specific quantitative skills affect one's utilization of base-rate information?

A base-rate is the relative frequency with which an event occurs or an attribute is present in a population (Koehler, 1989). Myriad research (e.g., Bar-Hillel, 1980; Kahneman & Tversky, 1973; Tversky & Kahneman, 1974) suggests that individuals fail to utilize base-rate information appropriately in the presence of case-specific information. This tendency is referred to as the "base-rate fallacy."

Gender and Quantitative Ability

Some of the most heated debates within the field of psychology have centered around the issue of gender and its relationship with quantitative ability. Although it is difficult to understand the association between gender and one's quantitative skills, many researchers now believe that (a) overall differences in mathematics performance are not apparent in early childhood, (b) sex differences favoring males begin to appear in adolescence but are highly dependent upon mathematical content area and the population from which the sample is selected, and (c) women traditionally receive higher grades in high school and college mathematics courses but fail to enroll in more advanced courses commensurate

with their male colleagues (de Wolf, 1981). While sex differences in quantitative ability have been reported on many occasions (Benbow & Stanley, 1980; de Wolf, 1981; Halpern, 1986), the effect size or significance of these differences has been an issue of great contention.

EXPERIMENT #1

Method

Subjects

Subjects were 216 students enrolled in an introductory psychology course at the University of Vermont during the Fall Semester of 1991. Subjects were randomly assigned one version of the "Cab Problem," assured of anonymity, and were fully debriefed at the conclusion of the experiment.

Cab Problem and Manipulations

Each version of the "Cab Problem" presented the following scenario:

> A cab was involved in a hit-and-run accident at night. Two cab companies, the "Green" and the "Blue" operate in the city. You are given the following information:
>
> (a) 90% of the cabs in the city are blue and 10% are green,
>
> (b) a witness identified the cab as green. The court tested the reliability of the witness under the same circumstances existing on the night of the accident and concluded that the witness correctly identified each one of the two colors 80 (55)% of the time and failed 20 (45%)% of the time.
>
> Based on these two pieces of information, what is the probability that the cab involved in the accident was blue rather than green?_____ (Please answer between 0% and 100%).

Three manipulations were crossed resulting in a 2 (Gender) X 2 (Order) X 2 (Witness-Accuracy Rate) design. Sixty-two percent of the subjects were female, while 38% were male. Approximately one-half of the "Cab Problems" presented the base-rates first followed by the witness accuracy information, while the remaining "Cab Problems" presented the witness-accuracy information before the base-rates. The "Witness Accuracy Rate" manipulation also contained two conditions. Roughly half the subjects were informed that the witness correctly identified each cab color 55% of the time and failed 45% of the time, while the other half were informed that the witness correctly identified each cab color 80% of the time and failed 20% of the time.

Results

The mean probability estimate across all conditions was $\bar{X}$=51.07%, s=29.03. A 2 X 2 X 2 Analysis of Variance demonstrated that "Order of Information" had a significant effect on subjects' probability estimates $F(1,208)=13.88$, $p=.0003$. Subjects who received the case-specific information last reported a mean probability estimate of 43.8, while those subjects who received base-rate information last reported a mean probability estimate of 59.1 (which is closer to the population base-rate of blue cabs - 90%). A significant main effect for "Witness Accuracy Rate" was also found, $F(1,208)=4.35$, $p=.038$. Subjects who were informed that the witness accuracy rate was 55% correct, 45% incorrect responded with a mean probability estimate of 55.3%, while those subjects who were informed that the witness accuracy rate was 80% correct, 20%

incorrect responded with a mean probability estimate of 46.7% (further from the base rate of blue cabs). The variable "Gender" was not found to have a reliable effect on subjects' probability estimates, $F(1,208)=.70$, $p=.40$. No two-way or three-way interactions were significant.

Insert Figure 1 about here

Discussion

The major findings in Experiment One were the main effects for "Order of Information," and "Witness Accuracy Rate." While many early investigations reported that the order of base and case information does not affect base-rate utilization (i.e., Borgida & Brekke, 1981), the current study is in accord with more recent research suggesting that base rates are weighted more heavily when presented after case-specific information (Heckman & Powell, 1991; Krosnick, Li, and Lehman, 1990). One implication of these recent findings is that a more quantitatively-oriented meta analysis of the base-rate literature would be appropriate (at least for the variable order of information).

The main effect for "Witness Accuracy Rate" supports the findings of several previous base-rate investigations (e.g., Hinz, Tindale, Nagao, Davis, & Robertson, 1988). Manipulating the accuracy of the case-specific information is common to many base-rate studies, and the typical finding is that subjects are sensitive to this change in the case-specific value -- as the

accuracy of the case-specific information increases, so does the subjects' likelihood of incorporating this information. Subjects' responses in the current study appeared to accommodate this tendency.

Lastly, it was concluded from Experiment One that base rates are utilized (although this utilization is far from optimal). Thirty-four subjects (16%) reported a probability estimate identical to that of the base-rate value, while only 17 subjects (8%) reported a probability estimate identical to the case-specific information (Witness Accuracy Rate). Therefore, it was concluded that 165 subjects (76%) attempted to integrate base-rate and case-specific information into their probability estimate. This supported Heckman and Powell (1991), who reported that 80% of subjects responding to a similar "Cab Problem" attempted to combine base and case information when making decisions.

However, it is somewhat perplexing that base rates were not utilized to an even greater degree, given the fact that subjects were asked to respond with a probability estimate that the cab in question was blue. One could hypothesize that question wording of this type would have subjects focusing on the base-rate information, at least more so than the case-specific information. Perhaps the current findings suggest that subjects do not look back at the information at all, and that they make their probability estimates immediately after reading the problem using only the information they have retained in short-term memory.

EXPERIMENT TWO

While many investigations have examined how individuals utilize base rates, few investigations have examined the impact of non-diagnostic base rates on decision-making processes. A non-diagnostic base rate is information (usually expressed in percentage format) that, among other things, changes the amount of elements in a population but does not change the relative percentages of elements comprising the population. Another way to view non-diagnostic base-rates is that they are information that is not necessary to generate a correct solution to a problem. To better understand the role of non-diagnostic base-rate information, consider the following example:

> Forty students (20 males and 20 females) comprise the enrollment of a statistics course (therefore, 50% of the students are male and 50% are female). However, on any given day, 20% of each sex is absent from class.

If presented the question, "On any given day, what percentage of the class is female?" the answer would still be 50%. Although the non-diagnostic base rate changes the overall number of students in attendance, it does not change the relative percentages of students comprising class attendance. Heckman and Powell (1991) found that subjects errantly integrated this non-diagnostic base rate into their decision-making process.

Experiment Two attempted to investigate (1) how gender was related to one's ability to work with non-diagnostic base-rate information, and (2) how a non-diagnostic base rate (i.e., "Out-of-Commission Rate") would affect subjects' probability estimates. It

was hypothesized that subjects would incorporate the non-diagnostic "Out-of-Commission Rate" (CommRate) incorrectly into the decision-making process and that, given the sex differences believed to exist regarding the solution of applied arithmetic problems, males would utilize non-diagnostic base rates more appropriately (i.e., provide a mean response closer to 55% than would females).

Method

Subjects

One hundred-fifty five undergraduate students enrolled in an introductory psychology course at the University of Vermont during the Fall Semester of 1991 were asked to read and complete one of three versions of the "Shuttle Problem," a modified version of Kahneman and Tversky's "Cab Problem." Subjects were assured on several occasions that their answers would remain anonymous and were fully debriefed at the end of the experimental session.

Shuttle Problem and Procedure

Subjects were randomly assigned one version of the "Shuttle Problem." A basic form of this problem is:

> The "Yellow" shuttle bus service and the "Blue" shuttle bus service are the only two shuttle services operating in the city. 55% of the shuttles in the city are yellow, and 45% of the shuttles are blue. At any given moment, 30% of each shuttle service's vehicles are in the shop for maintenance. An individual reports seeing a bus drive through a red light What is your estimated probability that the individual observed a yellow bus drive through the red light?_____ (Please answer with a percentage).

Two manipulations were crossed in a 3 X 2 design (three levels of the "Out-of-Commission Rate" and subjects' gender). Eighty-nine

(57%) subjects were female and 66 (43%) were male. The "Out-of-Commission Rate" specified a certain percentage (No Information, 30%, or 60%) of shuttles that were rendered out-of-commission and in the shop for maintenance. In all versions of the "Shuttle Problem," subjects were informed that 55% of the shuttles were yellow and 45% were blue. Due to the properties of the non-diagnostic "Out-of-Commission" base rate, it is argued that there is only one correct solution for all three versions of the "Shuttle Problem," that being 55%.

Results

The overall mean response was found to be 45.65%, s=15.71. The three means for the "Out-of-Commission" conditions (collapsed across both levels of "Gender") were as follows: Control Group: $\bar{X}$=51.69%, 30% Group: $\bar{X}$=44.86%, and 60% Group: $\bar{X}$=39.63%. The mean response for male subjects was 50.4%, while the mean response for female subjects was 42.2%.

A 3 X 2 Analysis of Variance reported a significant effect for "Out-of-Commission Rate" $F(2,149)=8.52$, $p=.0003$, as well as a significant effect for "Gender" $F(1,149)=12.79$, $p=.0005$. Post-hoc tests on the three means of "CommRate" revealed significant pairwise differences in two of the three comparisons, $\bar{X}_{\text{No Info}}= 51.7$ vs. $\bar{X}_{30\%}= 44.9$, $p < .05$, and $\bar{X}_{\text{No Info}}= 51.7$ vs. $\bar{X}_{60\%}=39.6$, $p < .05$. No significant "Gender X Out-of-Commission Rate" interaction was found.

Insert Figure 2 about here

Discussion

The primary findings in Experiment Two were main effects for "Out-of-Commission Rate," and "Gender." The main effect for "Out-of-Commission Rate" demonstrated that subjects did not correctly identify the mathematical properties of the non-diagnostic base rate. This finding supported a similar finding by Heckman and Powell (1991), who reported that subjects errantly incorporated non-essential base-rate information into the decision-making process.

A closer examination of the main effect for "Gender" reveals that males reported a mean probability estimate closer to the correct answer than did females. Specifically, males reported a mean probability estimate of 50.4% and females reported a mean probability estimate of 42.2%.

Implications and Future Research

The major objectives of this investigation were to demonstrate that (1) individual differences and the inappropriate application of some basic principles of arithmetic may account for errors observed in traditional base-rate investigations, and (2) that base-rate utilization is affected by the sequential ordering of case-specific and base-rate information as well as the numeric value of the case-specific information. The results of this investigation, to a certain extent, support these conclusions.

A more global perspective of this study (and many other related studies), however, suggests that this investigation failed to explore the more critical areas of base-rate utilization. The

main effect for "Order of Information" in Experiment One indicates that base rates are utilized more when presented after case-specific information. However, this finding doesn't explain why the information is processed this way. Is the increasing number of findings associated with an effect for order related to a recency effect? If so, the recency effect explanation should be tested empirically.

The more prominent theories regarding base-rate utilization (e.g., representativeness, causality, vividness) need to be empirically tested, not just submitted to tests of replication where, typically, the only difference between investigations is the type of word problem utilized. For example, if the theory of representativeness is going to be used to explain base-rate utilization, researchers must operationalize more empirical definitions of representativeness. How representative does something have to be before it is integrated into the decision-making process? Or, how vivid does information need to be before it will be integrated into one's decision? Is there an ordinal or interval scale on which vividness can be measured, and could this "vividness scale" be utilized to predict the degree to which information will be utilized in base-rate problems?

Researchers in the base-rate domain should attempt to develop more empirical models that eventually predict, explain, and allow one to understand base-rate utilization. Many investigations in the base-rate literature fall short of this objective. As a case in point, Argote, Devadas, and Melone (1990) reported that groups

integrated base and case information differently than did individuals when solving Kahneman and Tversky's "Lawyer-Engineer" problem. More specifically, Argote et al. found that groups ignored base rates in the presence of representative individuating information and paid less attention to base-rates than did individuals, but utilized base-rate information more appropriately than individuals when the individuating information was not representative. While this investigation is somewhat unique, how would these findings lend themselves to developing techniques that could be used to optimize base-rate utilization? These are just a few of the important empirical questions base-rate researchers should be considering as they develop base-rate test protocol and theory.

Perhaps answers to the enigmatic utilization (and non utilization) of base-rate information lie in areas such as fundamental learning theory, experience, or more latent cognitive processes. If so, the merits of these hypotheses will not be discovered merely by employing variables that provide little insight into base-rate utilization. Answers to the complex psychological phenomenon of base-rate utilization will most likely only be uncovered when researchers attempt to experimentally manipulate more quantifiable variables conjectured to influence base-rate utilization and affect decision-making strategies.

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FIG. 1. EFFECTS OF ORDER AND WITNESS ACCURACY RATE

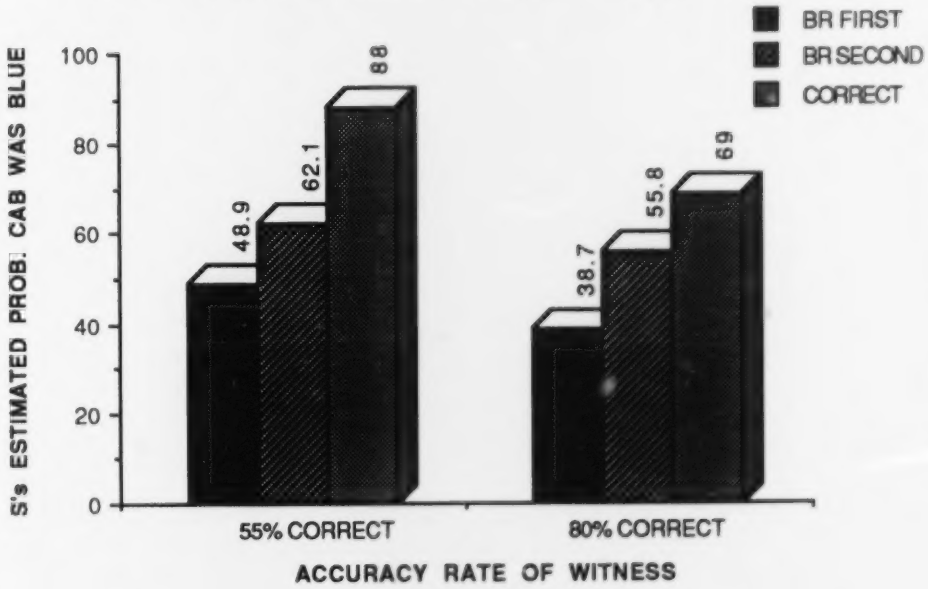

FIG. 2. GENDER AND COMMRATE'S EFFECTS ON PROB. ESTIMATES